TYPE 1607-P41, -P42, -P43, -P44

TRANSISTOR MOUNT ACCESSORIES

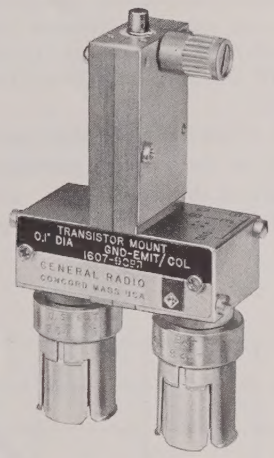


Figure 1-1. Type 1607 Transistor Mount with transistor fully seated in socket (typical). Type 1607-P30 Damper is installed at upper right.

SECTION 1

INTRODUCTION

1.1 PURPOSE.

The Type 1607-P41, -P42, -P43, and -P44 Transistor Mounts are accessories for the Type 1607-A Transfer Function and Immittance Bridge used to measure transistor parameters in the frequency range 25 Mc/s to 1500 Mc/s. The mounts are employed with the bridge to measure transistor Y, Z, and h parameters. They can also be used to measure semiconductor diodes, when the packaging configuration permits installation.

The mounts can be used at other frequencies (dc to 5 Gc/s) and with other instruments (refer to Appendix A).

These instructions pertain to the devices listed in Table 1-1 and shown in Figure 1-1.

TABLE 1-1

TYPE 1607 TRANSISTOR MOUNT ACCESSORIES

Type Number	*Part Number*	*Description*
1607-P41	1607-9641	Long-lead; 4-lead grounded-base; for 0.2-inch-diameter pin circle transistors.
1607-P42	1607-9642	Long-lead; 4-lead grounded-emitter and grounded-collector; for 0.2-inch-diameter pin circle transistors.
1607-P43	1607-9643	Long-lead; 4-lead grounded-base; for 0.1-inch-diameter pin circle transistors.
1607-P44	1607-9644	Long-lead; 4-lead grounded-emitter and grounded-collector; for 0.1-inch-diameter pin circle transistors.

1.2 DESCRIPTION.

These mounts, or test jigs, accept the full length of most transistor leads (up to two inches). The leads plug into hollow contact tubes in the mount. As a result, the leads (from about 1/32 inch from the transistor header out to the lead-tips) are completely shielded. Small bends or irregularities in the leads, therefore, do not affect measurement.

These mounts offer good measurement accuracy because the coaxial lines that connect to the transistor are small in diameter, so that the discontinuity arising from the transistor-to-mount connection is minimized. In addition, the steps in diameter and the 90° bends have been carefully compensated to reduce reflecti ons. Typical VSWR characteristics for all mounts are shown in Figure 1-2.

Additional advantages of these mounts are complete accessibility to the socket, provision for attachment of a heat-sink to the mount body, and provision for a fourth lead in the mount (which is dc grounded).

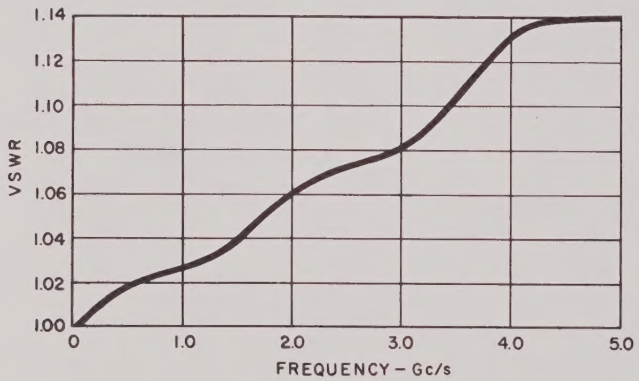


Figure 1-2. Typical VSWR at GR874 connector with transistor connection point terminated in 50 ohms.

The electrical length of the mounts to the reference plane, located 0.025 inch below the top of the socket, is 9.5 cm, approximately.

A damper unit, Type 1607-P30, is furnished with each mount to suppress oscillation likely to occur with high-gain transistors.

CAUTION

The protective cap should be on the damper tip when the damper is not in use, in order to protect the tip. A bent tip can cause bias shorting.

Since bias is applied through an isolating filter system in the Type 1607-A bridge, there is no provision in the mount itself to bias the transistor. Transistor packages compatible with the mounts are listed in Table 1-2.

TABLE 1-2

COMPATIBLE TRANSISTOR PACKAGES

Mount Type	*Transistors packages accepted*
1607-P41 -P42	TO-5, 9, 11, 12, 16, 26, 31, 33, 37, 38, 39, 43; MD-14; MM-4, 8; MT-13, 20, 28, 37; RO-2, 3, 4, 5, 10, 24, 30, 33, 34, 46, 49, 50, 61, 62, 79, etc.
1607-P43 -P44	TO-18, 28, 52, 54; MT-30; 38 RO-44,48, 51, 64, 65, 66, 70, 73, 78; U-3; X-8; etc.

The mounts are fitted with a pair of GR874 coaxial connectors so spaced that they plug directly into the INPUT and OUTPUT connectors located at the NETWORK UNDER TEST station of the Type 1607-A bridge.

The socket is made of polycarbonate, an extremely tough plastic with a dielectric constant of 2.73.

Refer to the bridge instruction book for detailed transistor-measurement procedures involving the mounts.

1.3 ACCESSORIES REQUIRED.

The 1607-P40 Termination Kit, consisting of open-circuit, short-circuit, and U-section units, is available for use interchangeably with all mounts. The kit is required for line-length adjustment procedures with the bridge. The Type 1607-P40 Termination Kit (see Figure 1-3) contains a Type 874-W010 Open-Circuit, a Type 874-WN10 Short-Circuit, and a Type 874-U10 U-Section. This kit permits adjustment of the bridge lines to place the point of measurement 0.025 inch below the top of the mount socket.

Figure 1-3. Type 1607-P40 Termination Kit. Accessory to all Type 1607 Transistor Mounts.

Each element of the kit is fitted with the GR874 coaxial connector for convenient use with the INPUT and OUTPUT connectors of the bridge.

A procedure for approximate setting of the lines, when this kit is not used, is given in paragraph 3.7, but is not recommended.

SECTION 2

PRINCIPLES OF OPERATION

2.1 GENERAL.

At higher radio frequencies, the method of connection of an unknown device to a measuring instrument of any kind is critical. Reproducible measurements can be made only if a standard method of connection can be achieved. Such is the function of these transistor mounts with respect to the Type 1607-A bridge.

The ultimate objective with accessories of this kind, user convenience, is directly related to the number of transistor devices with which they can be used. These mounts are compatible with over 50 common transistor packages that possess either a 0.1- or 0.2-inch diameter pin circle, as listed in Table 1-2. Moreover, the mounts permit measurements in all three basic transistor-circuit configurations and will accommodate four-lead devices commonly used at higher frequencies.

2.2 REFERENCE PLANE.

The mount reference plane is that point in the mount socket at which the immittance is the value indicated by the measurement instrument. It is determined by placement of either an open-circuit or a short-circuit at the transistor terminals of the mount. In practice, however, it is determined by substitution of open-circuited or short-circuited lengths of low-loss transmission lines in place of the mount. Special terminations required to set up the reference plane with these mounts are contained in the Type 1607-P40 Termination Kit.

The lengths of these lines are carefully chosen to be the same as the lengths of transmission line in the mount. Since fringing effects are small in these mounts, the mount, with the transistor removed, generally yields a more accurate determination of the

open-circuit reference plane. The electrical length of each mount leg and the location of the reference plane are shown in Figure 2-1.

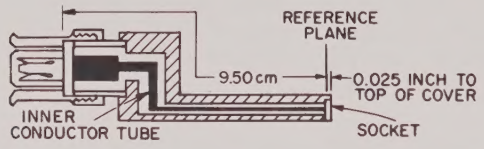


Figure 2-1. Cross-section of one side of a typical transistor mount.

2.3 LEAD-LENGTH EFFECTS.

The parasitic inductance and capacitance of transistor leads are minimized by connection very close to the transistor header in these mounts. If a transistor package, other than one of those listed in Table 1-2, is to be measured, this inductance and capacitance can be significant, because the transistor most likely cannot be fully seated.

Table 2-1 lists the approximate effects of the exposed leads.

2.4 TRANSISTOR OSCILLATION.

Oscillation can occur when high-gain transistors are connected to the measuring instrument. This oscillation can be low-frequency and occur through the bias system. Or, it can be high-frequency and occur because of the existence of sufficiently high-Q circuits in the bridge or measurement instrument.

2.5 CONTROL OF HIGH-FREQUENCY OSCILLATION

This oscillation can be evident or not, as described in paragraph 3.4. As a general precaution, use the Type 1607-P30 screw-insertion damper (supplied) to suppress it. The damper contains a 50-ohm resistor which is dc-blocked by a 1000-pF capacitor (see Figure 2-2). When installed, it places essentially 50-ohms resistance in shunt with the appropriate transistor lead, 3/32 inch from the reference plane. It threads into a tapped hole at either side of the mount. The damper cannot be inserted indiscriminately because it can shunt the measured value of the unknown or shunt an open circuit at the transistor reference terminals.

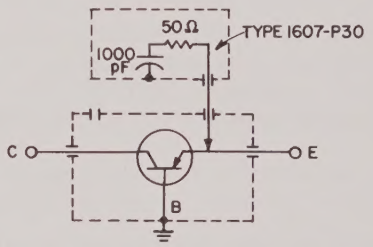


Figure 2-2. Damper circuit installed on emitter lead of a grounded base mount.

TABLE 2-1

APPROXIMATE HF PARASITIC INDUCTANCE AND CAPACITANCE OF TRANSISTOR-LEAD PAIRS, 0.0175-IN-DIAMETER WIRE

Mount Type 1607	*Wire Spacing (inch)*	*L (nH/inch)*	*C (pF/inch)*
-P43, -P44	0.071	21	0.34
	0.100	25	0.29
-P41, -P42	0.141	28	0.25
	0.200	32	0.23

NOTE

The inductance per unit length of a single 0.0175-inch-diameter wire is 23 nH/inch.

SECTION 3

OPERATION

3.1 TRANSISTOR PREPARATION AND INSERTION.

The mounts can accept transistor lead lengths up to 2 inches. For greatest accuracy and less wear and tear on the mount, the leads should be short, straight, and perpendicular to the header. When long leads are not required; they should be cut down to approximately 3/16 inch, the minimum lead length that can be accepted is 3/32 inches.

NOTE

Measurement is independent of lead length.

Insertion of the transistor, when full leads must be retained, is facilitated if some leads are shortened slightly. Then, insert the longest lead first.

3.2 TYPE 1607-P41 AND -P43 MOUNT USE.

The lead pattern for these grounded-base mounts is shown in Figure 3-1. The marker engraved on the socket indicates the proper placement of the transistor tab.

The C and E terminals connect to the coaxial-line inner-conductor tubes, which connect to the center conductors of the coaxial connectors on the mount. The B terminal is dc-grounded to the mount body, as is the fourth lead. The pin-circle diameter is 0.200 inch for the Type 1607-P41 mount and 0.100 inch for the Type 1607-P43 mount. The Type 1607-P41 mount accepts lead diameters from 0.014 inch to 0.032 inch thick. The Type 1607-P43 mount accepts leads from 0.014 inch to 0.021 inch in diameter.

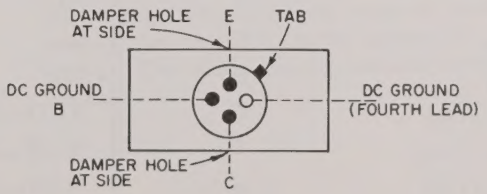


Figure 3-1. Grounded-base mount, top view.

3.3 TYPES 1607-P42 and -P44 MOUNT USE.

The lead patterns for these combination grounded-emitter/grounded-collector mounts are shown in Figures 3-2 and 3-3. The black and red markers on the socket indicate the directions of the transistor tab for the two connections. The pin-circle diameter is 0.200 inch for the Type 1607-P42 mount and 0.100 inch for the Type 1607-P44 mount.

The C and B terminals of Figure 3-2 connect to the coaxial-line inner-conductor tubes, which connect to the center conductors of the coaxial connectors on the mount. The E terminal is dc-grounded to the mount body, as is the fourth lead.

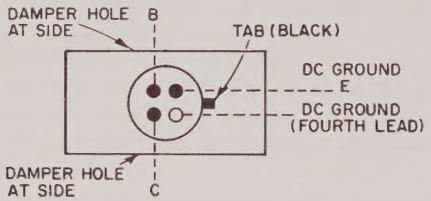


Figure 3-2. Grounded-emitter mount, top view.

The B and E terminals of Figure 3-3 connect to the coaxial-line inner-conductor tubes, which connect to the coaxial connectors on the mount. The C terminal is dc-grounded to the mount body, as is the fourth lead.

The Type 1607-P42 mount accepts lead diameters from 0.014 inch to 0.032 inch thick. The Type 1607-P44 mount accepts leads from 0.014 inch to 0.021 inch in diameter.

3.4 TRANSISTOR OSCILLATION SUPPRESSION

3.4.1 GENERAL.

Oscillation may be encountered in the use of the mounts, as indicated by the following:

1. Inability to obtain a null.
2. Indication of ridiculous immittance values.
3. A discontinuous increase in transistor current or indicated immittance, as the bias is increased from zero to the operating value.
4. Strong hand-capacitance effects in the vicinity of the transistor, indicated by variation of the detector-output level.
5. The presence of ac signals at the bias terminals, in the event of low-frequency oscillation (detectable with an appropriate oscilloscope).

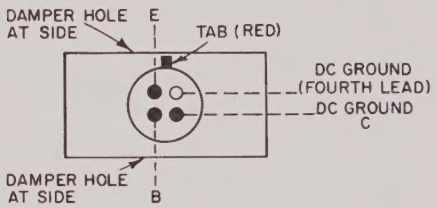


Figure 3-3. Grounded-collector mount, top view.

3.4.2 DAMPER APPLICATIONS.

Generally, the Type 1607-P30 Damper furnished with each mount is useful to eliminate oscillation. Table 3-1 lists the measurements for which the damper can be utilized for each mount and also the transistor lead to

TABLE 3-1
PERMISSIBLE DAMPER CONNECTIONS

Type 1607-P41, -P43 Mounts		*Type 1607-P42, -P44 Mounts*			
Grounded Base Measurement	*Connect Damper To (Figure 3-1)*	*Grounded Emitter Measurement*	*Connect Damper To (Figure 3-2)*	*Grounded Collector Measurement*	*Connect Damper To (Figure 3-3)*
h_{fb}, α, I_2/I_1	C	h_{fe}, β, I_2/I_1	C	I_2/I_1	E
α_r	E	β_r	B	Y_{11}	E
h_{rb}	C	h_{re}	C	Y_{22}	B
h_{ib}	C	h_{ie}	C	Y_{12}	E or B
$Y_{11}(Y_{ib})$	C	$Y_{11}(Y_{ie})$	C	Y_{21}	E or B
$Y_{22}(Y_{ob})$	E	$Y_{22}(Y_{oe})$	B		
$Y_{12}(Y_{rb})$	C or E	$Y_{12}(Y_{re})$	C or B		
$Y_{21}(Y_{fb})$	C or E	$Y_{21}(Y_{fe})$	C or B		

which the damper should be connected. Refer to paragraphs 3-2 and 3-3 for transistor orientations on the mounts.

3.4.3 OTHER OSCILLATION SUPPRESSION MEASURES.

When the damper cannot be used, measures to eliminate oscillation are:

1. Set up different combinations of INPUT and OUTPUT LINE settings on the bridge, i.e., add or subtract a half wave to either line, or both lines.
2. Determine whether the oscillation is low or high in frequency; an oscilloscope at the bias terminals can be used to detect the former. If the frequency is low, oscillation is caused by the presence of too high an impedance in the bias supply. Bypass the bias terminals with a large capacitor, e.g., 0.5 μF, to eliminate this effect. When common-base bias is employed with common-emitter rf measurements, low-frequency oscillation can occur. Insert an rf choke in series with the collector supply to eliminate this oscillation.
3. Shift the measurement frequency slightly. The resulting reset of the adjustable lines can disturb phase relations sufficiently to stop oscillation.

3.5 MEASUREMENT OF Y OR h ADMITTANCES << 20 MHOS.

To obtain the ultimate accuracy in the measurement of small admittances:

1. Make the final OUTPUT-LINE adjustment with the open-circuited mount (less transistor) installed in place of the Type 874-W010 termination.
2. Install the Type 1607-P10 or -P11 Multiplier Plate (in the bridge) and subtract the residual conductance (owing to line and mount loss), in accordance with paragraph 3.2.10 of the Type 1607-A instruction manual.

3.6 MEASUREMENT OF h_o.

Transistors generally exhibit a negative real part in h_o, or else they oscillate. Since the Type 1607-A bridge does not ordinarily measure negative conductance, it is sometimes necessary to measure other quantities and to calculate h_o from them as follows:

$$h_{oe} = Y_{oe} + \frac{h_{re}h_{fe}}{h_{ie}}$$

$$h_{ob} = Y_{ob} + \frac{h_{rb}h_{fb}}{h_{ib}}$$

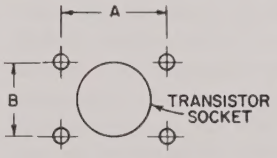
There is, however, a small residual loss in the bridge (and it can be increased by addition of line sections); frequently, the net conductance is zero or positive. This permits direct measurement of h_o and, in fact, is the most accurate measurement. The loss is accounted for in the measurement procedure of the Type 1607-A instruction manual, paragraph 3.2.10.1. Oscillation from this source cannot be suppressed by the use of the damper, because the damper would either shunt the output admittance or shunt the open circuit at the input (depending upon where it is installed). If oscillation occurs, its presence can be detected by the techniques given in paragraph 3.4.1 and it can be eliminated in some cases by the methods given in paragraph 3.4.3.

3.7 USE WITHOUT TYPE 1607-P40 KIT.

When the Type 1607-P40 Termination Kit is not available for line adjustment use, approximate setting of the bridge lines can be made by use of the Type 874-W05, -WN5, and -U terminations furnished with the Type 1607-A bridge; make the normal adjustments with these units. Then, to obtain the approximately correct settings for these mounts, shorten both the OUTPUT LINE and INPUT LINE 5.0 cm.

3.8 HEAT-SINK ATTACHMENT.

Four tapped holes are provided at the top of each mount to which a heat sink may be bolted. The thread is 2-56, the spacing is shown in Figure 3-4.



Mount Type	A	B
1607-P41	0.625	0.434
1607-P42	0.625	0.376
1607-P43	0.438	0.313
1607-P44	0.438	0.284

Figure 3-4. Heat-sink attachment-hole spacings.

3.9 LEAD STRAIGHTENING.

Maximum accuracy can be obtained, and less wear will occur, if the transistor leads are straight. A broad bladed tweezer is a useful device for lead straightening. The leads should protrude squarely from the header.

SECTION 4

SERVICE AND MAINTENANCE

4.1 WARRANTY.

General Radio warrants, that each new instrument sold direct is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, district office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

4.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest sales engineering office, requesting a "Returned Material Tag". Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.3 TROUBLE ANALYSIS.

If a mount is inoperative, a dc check should be performed to eliminate the possibility that a short from a lead tube to ground has developed. As evidence of a short circuit, look for continuity between the outer and inner conductors of the GR874 connectors.

This check should be repeated with the damper in place. If a short is detected, remove the damper and check it for dc shorts by measurement between the tip and body. Also inspect the damper tip to see if it is bent.

If a short is detected in the mount, it could be caused by dislocation of the contact tube bead supports. Subsequent paragraphs contain disassembly and replacement procedures.

4.4 DISASSEMBLY (Figure 4-1).

4.4.1 DISASSEMBLY OF BLOCKS.

The mounts can be disassembled for examination or replacement of the transistor-lead contact tubes and must be disassembled for replacement of the GR874 connectors.

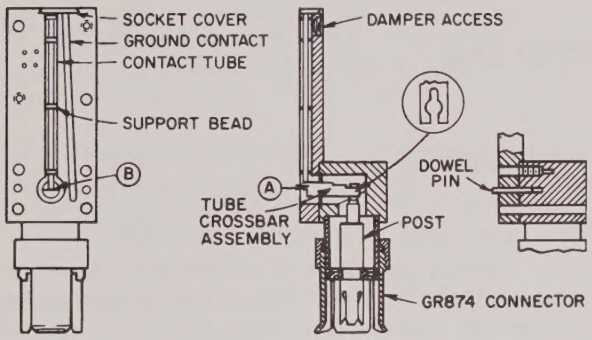


Figure 4-1. Cross-section views of typical mount.

The procedure is as follows:

CAUTION

The GR874 connectors should not be loosened or removed, unless the mount has been disassembled and the transistor-lead contact-tube has been removed.

a. Remove the 10 Phillips-head screws from the mount, including those on the nameplate.

b. Carefully pry the halves of the mount apart, keeping the partition flush with one of the halves; separate the halves completely. There are two dowel pins in the base blocks that resist the separation. The ground contacts can drop out; therefore, exercise care not to lose them.

c. Remove the partition from the one half along with the socket cover. Both contact tubes are now accessible for examination.

4.4.2 REPLACEMENT OF CONNECTORS.

a. Disassemble blocks as in paragraph 4.4.1.

b. Gently pry the lead contact tube to release the adhesive holding the support beads that insulate the tubes from the block.

c. Grasp the tube-cross-bar assembly at point A and snap the cross bar out from the post.

d. Remove the GR874 connector. Use of the Type 874-T0K Tool Kit is recommended.

4.4.3 REPLACEMENT OF CONTACT TUBES.

a. Disassemble blocks as in paragraph 4.4.1.

b. Gently pry apart to release the adhesive holding the support beads.

c. Unsolder the tube contact at point B and remove the assembly.

d. Replace the tube and the four beads; see Table 4-1 for part numbers.

e. Slip the beads on the tube, approximately as shown in Figure 4-1, and install the assembly.

f. Soft solder the tube contact at point B with a minimum amount of solder.

g. Cement the three lower beads to the contact tube with a 1/64-inch fillet of Polyweld 912*, or equivalent.

h. Cement the *outside* of the top bead to the mount body as in step g.

i. Reassemble the mount.

**American Phenolic Corp., Chicago, Illinois.*

NOTE

Mount socket cover with countersunk holes facing up.

TABLE 4-1

REPLACEABLE PARTS

Mount Type	*Contact Tube Part Number*	*Bead Part Number (4 per tube)*
1607-P41	*1607-6253*	*1607-7241*
1607-P42	*1607-6252*	
1607-P43	*1607-6251*	*1607-7240*
1607-P44	*1607-6250*	

APPENDIX A

USE WITH SLOTTED LINE

GENERAL.

These mounts can be used with any immittance-measurement instrument for transistor measurements to 5 Gc/s, if bias can be applied. A block diagram of a slotted-line system to measure input or output immittances (Y_{11}, Y_{22}, Z_{11}, Z_{22}, h_i, h_o) is given in Figure A-1. The recommended means of bias provision is the Type 874-FBL, a coaxial accessory with GR874 connectors.

Operate the slotted line with its input and detector terminals interchanged, in order to assure small-signal measurements, when a high degree of accuracy is desired. The Type 900-Q874 Adaptor will be required to connect the mount to the GR900 connector on the slotted line. The Type 874-LBA , a general-purpose line usable to 5 Gc/s, can also be employed if a high degree of accuracy is not required.

PROCEDURES (Figure A-1)

1. Z_{11}, Z_{22}, h_o MEASUREMENT

1.1 Open-circuit adjustment at Terminal B:

a. Connect the Type 874-W010 open-circuit termination (from Type 1607-P40 kit) to the slotted line and set the slotted-line carriage position to the null closest to its unknown terminals. Retain this setting for the next step.

b. Remove the Type 874-W010, and connect one leg of the Type 874-U to the slotted line and the other to the adjustable-stub, bias-filter, and elbow assembly. Adjust the stub for a null at the same slotted-line probe position.

1.2 Impedance Measurement:

a. Replace the Type 874-U10 termination with the Type 1607-P() mount; take care not to disturb the stub setting.

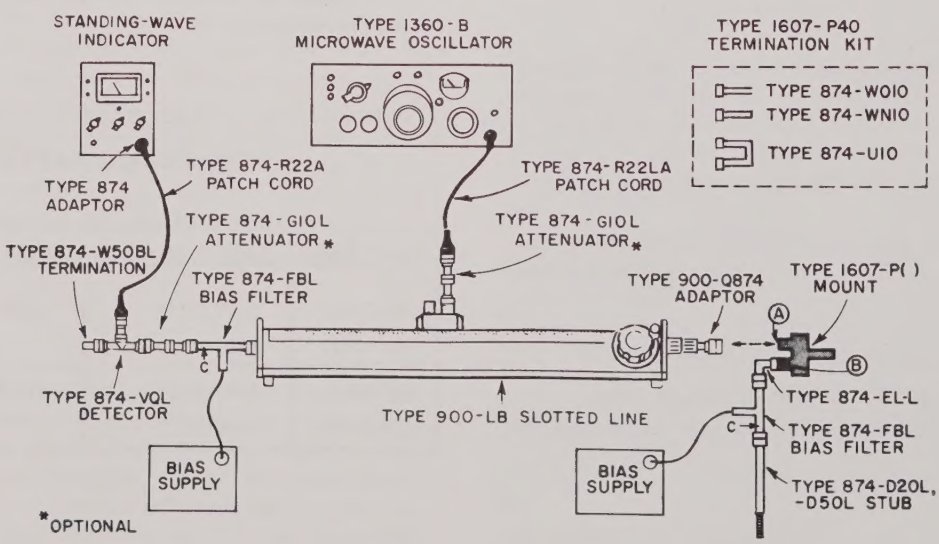


Figure A-1. Slotted-line use of transistor mount.

b. Insert the transistor and apply bias.

c. Measure the impedance at terminal A, according to standard slotted-line procedures (usually given in detail in the slotted-line instruction book).

NOTE

The damper cannot be used. If oscillation is encountered, refer to paragraph 3.4.3.

The reference plane, the point in the mount at which the above measurement is made, is 0.025 inch below the top of the transistor mount.

2. Y_{11}, Y_{22}, h_i MEASUREMENT.

2.1 Short-circuit adjustment at terminal B:

a. Connect the Type 874-WN10 Short-Circuit Termination (from the Type 1607-P40 kit) to the slotted-line and set the slotted-line carriage to the null position closest to its unknown terminals. Retain this setting for the next step.

b. Remove the Type 874-WN10 and connect one leg of the Type 874-U10 to the slotted line and the other to the adjustable stub, bias-filter, and elbow assembly.

c. Adjust the stub for a null at the same slotted-line probe position.

2.2 Admittance Measurement:

a. Replace the Type 874-U10 with the Type 1607-P() Mount; take care not to disturb the stub setting.

b. Insert the transistor and apply bias.

c. Measure the admittance at terminal A, according to standard slotted-line procedures.

NOTE

The damper can be used at the mount terminal connected to B, the short-circuit end.

The reference plane, the point in the mount at which the above measurement is made, is 0.025 inch below the top of the transistor mount.

MEASUREMENT ERROR

The slotted line permits measurement of transistor parameters beyond the frequency range of the Type 1607-A Transfer-Function and Immittance Bridge, i.e., to 5 Gc/s. The ultimate accuracy in this range is limited by the residual loss and discontinuities in the transistor mount and in the measuring instrument. Measurement procedures to account for this loss are given in most slotted-line manuals. The loss in the mount, when a small value of admittance or a large value of impedance is involved, is measured with the mount open-circuited (less transistor). The loss occurring in the mount, for a large value of admittance or a small value of impedance, can be measured with a short-circuited transistor header installed in the mount.

The discontinuities in the mount also limit the accuracy. The relatively small error resulting from this source is given in Figure 1-2.

It may be found occasionally that an insufficiently low short-circuit impedance or an insufficiently high open-circuit impedance is observed in the adjustment of the Type 874-D20L sliding short circuit when used with the Type 874-FBL. This is caused by the presence of a voltage maximum at the bias take-off choke. Insertion of an appropriate Type 874-L air line in front of the Type 874-FBL alleviates this problem.

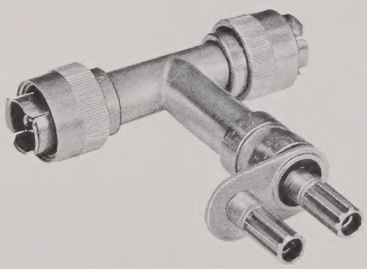


Figure A-2. Type 874-FBL Bias Insertion Unit.

U. S. Patent No. 2,548,457

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS 01781

617 369-4400 617 646-7400

SALES ENGINEERING OFFICES

NEW ENGLAND*
22 Baker Avenue
West Concord, Massachusetts 01781
Telephone 617 646-0550

METROPOLITAN NEW YORK*
Broad Avenue at Linden
Ridgefield, New Jersey 07657
Telephone N.Y. 212 964-2722
N.J. 201 943-3140

SYRACUSE
Pickard Building
East Molloy Road
Syracuse, New York 13211
Telephone 315 454-9323

PHILADELPHIA
Fort Washington Industrial Park
Fort Washington, Pennsylvania 19034
Telephone 215 646-8030

WASHINGTON* and BALTIMORE
11420 Rockville Pike
Rockville, Maryland 20852
Telephone 301 946-1600

ORLANDO
113 East Colonial Drive
Orlando, Florida 32801
Telephone 305 425-4671

CHICAGO*
6605 West North Avenue
Oak Park, Illinois 60302
Telephone 312 848-9400

CLEVELAND
5579 Pearl Road
Cleveland, Ohio 44129
Telephone 216 886-0150

LOS ANGELES*
1000 North Seward Street
Los Angeles, California 90038
Telephone 213 469-6201

SAN FRANCISCO
1186 Los Altos Avenue
Los Altos, California 94022
Telephone 415 948-8233

DALLAS*
2600 Stemmons Freeway, Suite 210
Dallas, Texas 75207
Telephone 214 637-2240

TORONTO*
99 Floral Parkway
Toronto 15, Ontario, Canada
Telephone 416 247-2171

MONTREAL
1255 Laird Boulevard
Town of Mount Royal, Quebec, Canada
Telephone 514 737-3673

www.manualsplus.com
1023274

* Repair services are available at these offices.

General Radio Company (Overseas), 8008 Zurich, Switzerland
General Radio Company (U.K.) Limited, Bourne End, Buckinghamshire, England
Representatives in Principal Overseas Countries

Form 1607-0141-B
December, 1965

Printed in USA